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Where Architecture Meets Biology: An Interview with Detlef Mertins

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Abstract

I began doing research on Mies van der Rohe in the early nineties, after Fritz Neumeyer had published his book *The Artless World*, (1994). Neumeyer foregrounds Mies' library, the books that Mies read. He was also the first to collect all the things that Mies himself wrote. One of the things that I found very surprising was that Mies was a reader of science, and especially of biology in the 1920s. He had a collection of about 40 books by the botanist Raoul Francé, the author of *Der Sanze als Erfinder* ("The Plant as Inventor," 1920). This was surprising, for I had always thought of modernism as an architecture of technology rather than an architecture that was imbued with organic aspirations and ethos. One thought of organic architecture more in terms of biomorphic form; in the German context, one thought of Hugo Häring, but not the straight-up-and-down, orthogonal architecture that Mies developed, or his expression of structure.

Disciplines

Architecture

Comments

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Where Architecture Meets Biology

An Interview with Detlef Mertins

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Detlef Mertins is an architect and historian known for his revisionist work on 20th-century architectural history. He is professor and chair of the architecture department at the University of Pennsylvania. His publications include an extended introduction to the theory of design as *Gestaltung* for the English edition of Walter Curt Behrendt's *The Victory of the New Building Style* (2000). He is currently completing a monograph on Ludwig Mies van der Rohe. He published the essay "Bioconstructivisms," on form-finding principles derived from biological ideas used by architects during the last 250 years, in Lars Spuybroek's *NOX: Machining Architecture* (2004).

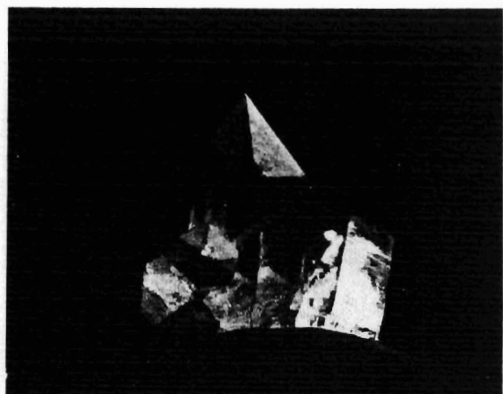
Where does the concept of bioconstructivism come from?

May I answer this slightly biographically? I began doing research on Mies van der Rohe in the early nineties, after Fritz Neumeyer had published his book *The Artless World* (1994). Neumeyer foregrounds Mies' library, the books that Mies read. He was also the first to collect all the things that Mies himself wrote. One of the things that I found very surprising was that Mies was a reader of science, and especially of biology in the 1920s. He had a collection of about 40 books by the botanist Raoul Francé, the author of *Der Pflanze als Erfinder* ("The Plant as Inventor," 1920). This was surprising, for I had always thought of modernism as an architecture of technology rather than an architecture that was imbued with organic aspirations and ethos. One thought of organic architecture more in terms of biomorphic form; in the German context, one thought of Hugo Häring, but not the straight-up-and-down, orthogonal architecture that Mies developed, or his expression of structure.

For me, this opened up a territory for research. It was Mies' personal library that facilitated an expansion of research into this field. Then one discovers these themes of architecture and biology in the Werkbund discourse and in a whole series of architects and artists of the period. I was also stimulated by Olivar Botar, who was doing a Ph.D. in Toronto on what he called the discourse of biocentrism in the 1920s and '30s in Central Europe. He pointed out that figures like El Lissitzky, László Moholy-Nagy, Hannes Meyer, Raoul Hausmann, Ernő Kállai and others were all readers of Raoul Francé. Since the work of Lissitzky, Moholy and Meyer was all super-technological for their day, it seemed that one should recast the notion of 1920s constructivism to incorporate this biologism. That's when I started to use the term "bioconstructivism" in my teaching and writing. It's not a term that they used at the time. It's a retroactive historian's glance, and at the same time it seems like a useful concept to bring into the contemporary, to make clear that there are continuities between then and now that we haven't adequately explored in the approach to technology and media, even among architects like Lars Spuybroek, Greg Lynn, Karl Chu and others, who are mining biology and biologic thought for experimental form-making.

Raoul Francé uses the term "biotechnics."

Yes, and he was not the only one. Patrick Geddes used that term earlier, and Lewis Mumford also used it later, but I don't think he knew Francé. Interestingly, Raoul Francé himself seems to have been influenced by the Werkbund discourse on the rationalization of technology. His approach to the idea that plants or organisms could be seen as prototypes of human tech-



DAUPHINÉER QUARZ



KRISTALL

cristal

KUGEL

sphère

FLÄCHE

étendue

STAB

barre

BAND

ruban

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spirale

KEGEL

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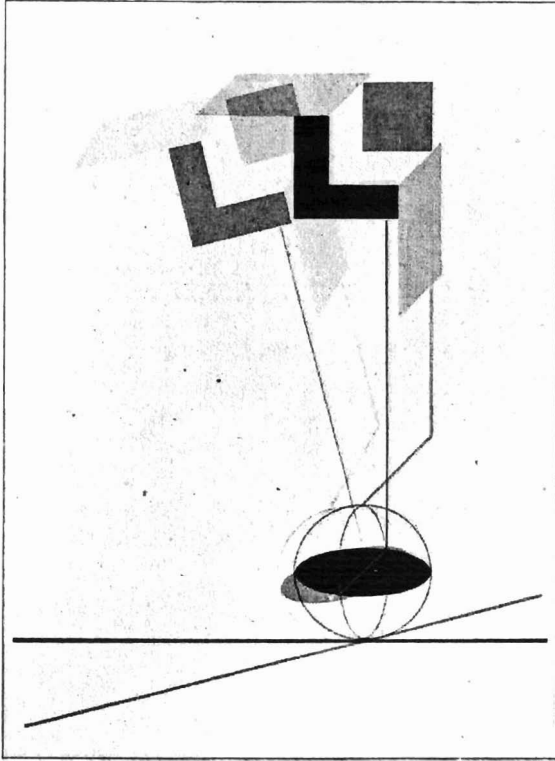
dAS SIND DIE GRUNDLEGENDEN TECHNISCHEN FORMEN DER GANZEN WELT. SIE GENÜGEN SÄMTLICHEN VORGÄNGEN DES GESAMTEN WELT-PROZESSES, UM SIE ZU IHREM OPTIMUM ZU GELEITEN. ALLES, WAS IST, SIND WOHL KOMBINATIONEN DIESER SIEBEN URFORMEN.

SIE SIND DAS GANZE UM UND AUF
 DER ARCHITEKTUR
 DER MASCHINENELEMENTE
 DER KRISTALLOGRAPHIE UND CHEMIE
 DER GEOGRAPHIE UND ASTRONOMIE
 DER KUNST
 JEDER TECHNIK
 JA DER GANZEN WELT.

Ce sont les formes techniques fondamentales de l'univers. Elles suffisent à toutes les opérations de la formation du monde pour les conduire à leur développement extrême. Tout ce qui est, est combinaison de ces sept formes primitives. C'est sur elles que reposent toute l'architecture, les éléments de la mécanique, la cristallographie, la chimie, la géographie, l'astronomie, l'art, toute technique et le monde entier.

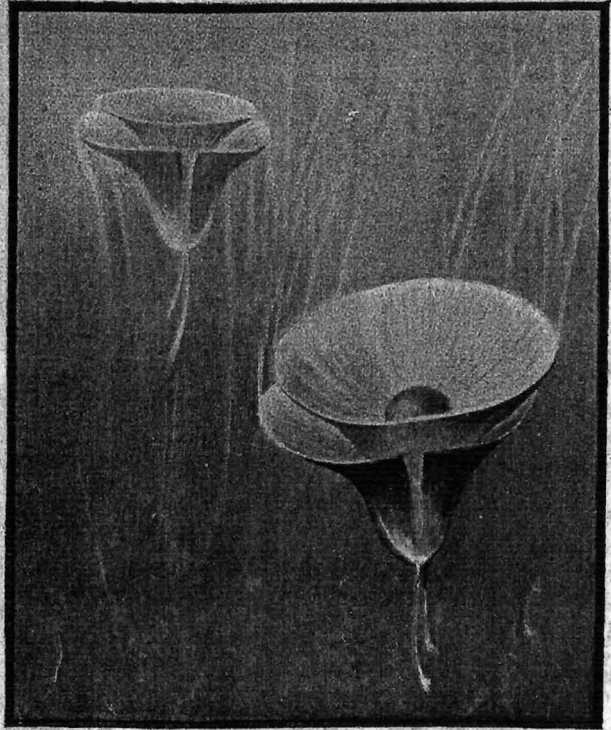
Spread from Merz no. 8/9 (April/June 1924), edited by Kurt Schwitters and El Lissitzky and titled Nasci. This juxtaposes a list of Raoul H. France's "seven Ur-forms of creation" (crystal, sphere, plane, rod, ribbon, screw, and cylinder) with one of Lissitzky's Proun compositions.

EL LISSITZKY



Kunstwerk ist Gleichgewicht. Dieses Gleichgewicht muß aber Resultat von maximalen Gegengewichten sein, um das statisch Gestaltete zur dynamischen Wirkung zu bringen.
L'oeuvre d'art c'est l'équilibre. Il faut que ce soit le résultat de contrepois maximums et par cela la création statique obtient l'effet dynamique.'

R. H. Francé
**Die Pflanze
als Erfinder**



Kosmos-Gesellschaft der Naturfreunde
Franck'sche Verlagshandlung-Stuttgart

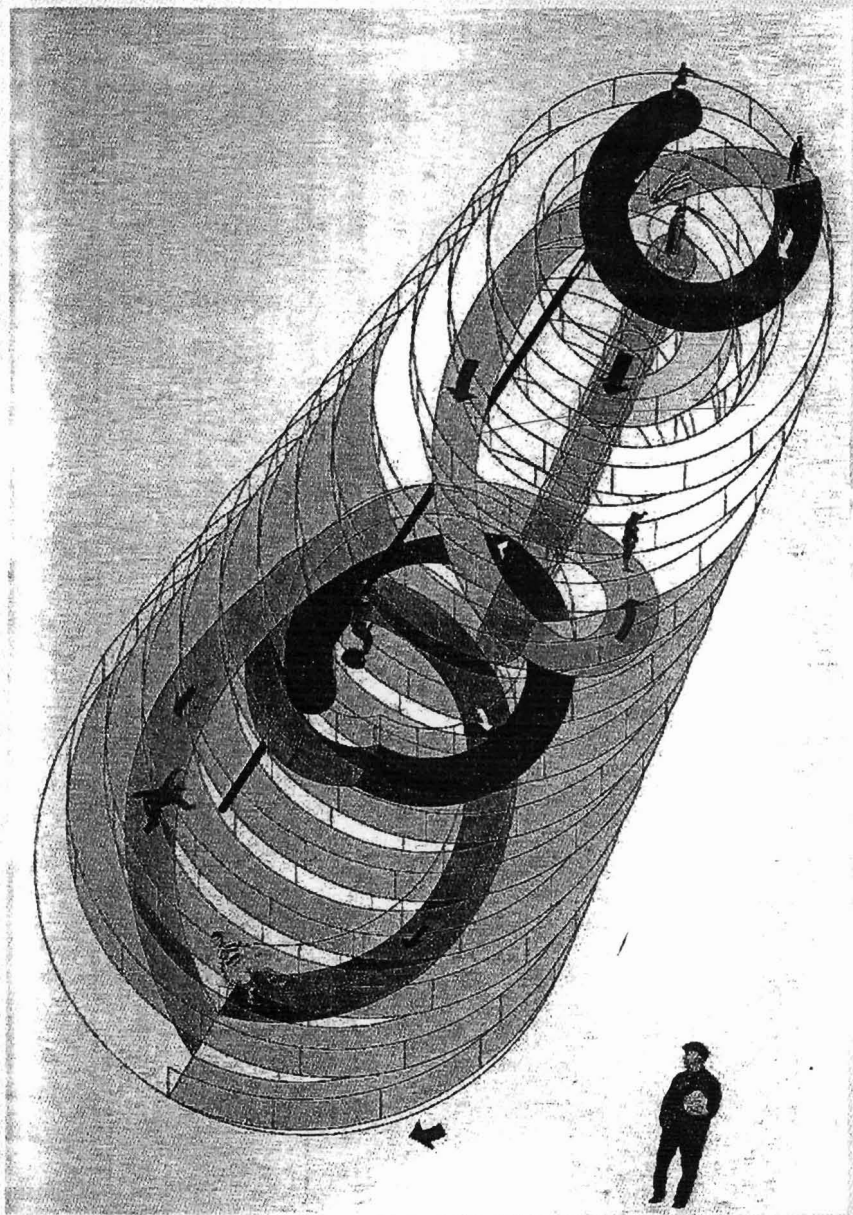
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nology is informed by an objectivist, rationalist orientation in design discourse. One of the ideas that comes to the fore at that moment is that form is not an a priori; it's not predetermined. Form is seen as the result of a process. That opens the door to the question of what kind of processes and media or means are involved in the making of form.

The architects and artists of the 1920s saw in Francé's biotechnics an argument for a scientific understanding of things like functionality – that form is the necessary result of a function – and of optimization. There are a host of other related categories in Francé: minimal means, the shortest path between two points, elementalism – the use of reduced, purified elements that cannot be further reduced as a way to achieve optimization – and also harmony, all of which were considered to be operative throughout the universe according to fixed laws. Francé presented an entire cosmology – his publisher was even called Kosmos – which someone like Lissitzky was very sympathetic with, since he was oriented towards a new cosmology of world reconstruction. Moholy-Nagy and other constructivists of the 1920s all wanted to have that kind of comprehensive, scientific worldview as a platform for their experimental work.

How did Mies use Francé?

I'm in the process of finishing a monograph on Mies, and it's one of the things that I've been trying to articulate. Mies' approach to the organic and the biotechnical is not functional, at least not in the conventional sense, but he does take notions of optimization, the rule of the minimum, and the quest for harmony. He takes something that in Francé is more of an underpinning than a foreground notion, and that is the relationship between organism and environment, for which Ernst Haeckel coined the science of ecology. Having read Frank Lloyd Wright describe his early buildings as organisms, I think Mies understood the building as an organism that is at work within its milieu or environment. Just as life forms evolve, so too do architecture and technology. For Mies, architecture needed to achieve a new harmony with its environment, because the environment had been changing in historical and material terms. This is the familiar modernist theme of being consistent with the times, which is usually thought of in terms of *zeitgeist* but could also be approached from an ecological and evolutionary perspective. Mies surveyed what was going on in the world and read widely. He was not only a reader of science; he was a reader in many fields. He wanted especially to understand how philosophers, theologians and scientists were thinking about the present condition, about the problematics of modernity, the metropolis, mass society, the loss of orientation and *Bildung*. He tried to develop a nascent worldview for which his architecture would be an active agent. It's an agent for the development of that new world in the same way that somebody like Lissitzky argued for world reconstruction. But Lissitzky said in 1924, "Enough of the machine ... I want to build limbs of nature." So Mies used Francé for an evolutionary and environmental underpinning. Take the idea that the building is an open construct to the landscape that allows



László Moholy-Nagy, with István Sebök, Kinetic-Constructive System: Structure with Movement Track for Play and Conveyance (1922/1928), photomontage and collage on bromure, Indian ink and watercolor on card, 76 x 54.5 cm (courtesy Theaterwissenschaftliches Institut der Universität Köln)

for movement and exchange between inside and outside. Again, this is a standard modernist trope, but it is informed by how science understands relationships of organisms to the environment. He also read Jakob von Uexküll, Hans Driesch and Paul Krannhals. Later, in America, he read D'Arcy Thompson, Erwin Schrödinger, Julian Huxley, Arthur Eddington and Lancelot Law Whyte.

Francé's ultimate goal was to articulate what in German would be called a *Lebenslehre*, a doctrine of life, a way of living, knowledge of how to live, and how to live well – in his terms, a healthy life too. I think the notion of health was central for his doctrine. The other thing that is very interesting about the artistic reception of Francé by people like Lissitzky and Moholy is that they take up the idea of emulating the constructive processes of nature, but their conception of the world is monistic. There's no divide between nature and humanity. The human is in nature already. They're interested in technological evolution as a way to open up an expanded horizon of experience, as a way to develop new functionalities, new relationships through invention. Moholy most famously concentrated on the question of vision and new optics. So for him, the camera, microscope, telescope, and film camera were technologies that expanded the human facility for vision, and revealed hidden worlds and new knowledge. New art and new architecture could have similar effects.

You can also think of this in terms of expanded capacities, expanded powers. There's a very interesting article by the Austrian artist-designer Friedrich Kiesler from 1939 on "co-realism" and "biotechniques," written when he was already in the United States. Bill Braham pointed me to this article, which is in his new anthology of writings on architectural technology. Kiesler defines his notion of co-reality as an exchange of interacting forces and situates the idea of expanding human capacities within it. He says that forms are "the visible trading posts of integrating and disintegrating forces, mutating at low rates of speed." He defines co-realism as the science of the exchange of relationships and forces, which emphasizes the dynamics of continual interaction between humanity and the environment, in which there is little or no distinction made between the natural and the technological. He distances himself from the notion of biotechnics, since it seems to privilege the natural over the human. And he says we shouldn't imitate how nature constructs things; we should be developing what he calls biotechniques that allow us to influence life in a desired direction. For instance, he wants to move from the assembly of structures to continuous construction.

Kiesler wants to develop "the potential of specific actions contained in any nucleus of human physiology, resulting in entirely new functions sustained by inventions." This set of ideas still uses the ecological model of the

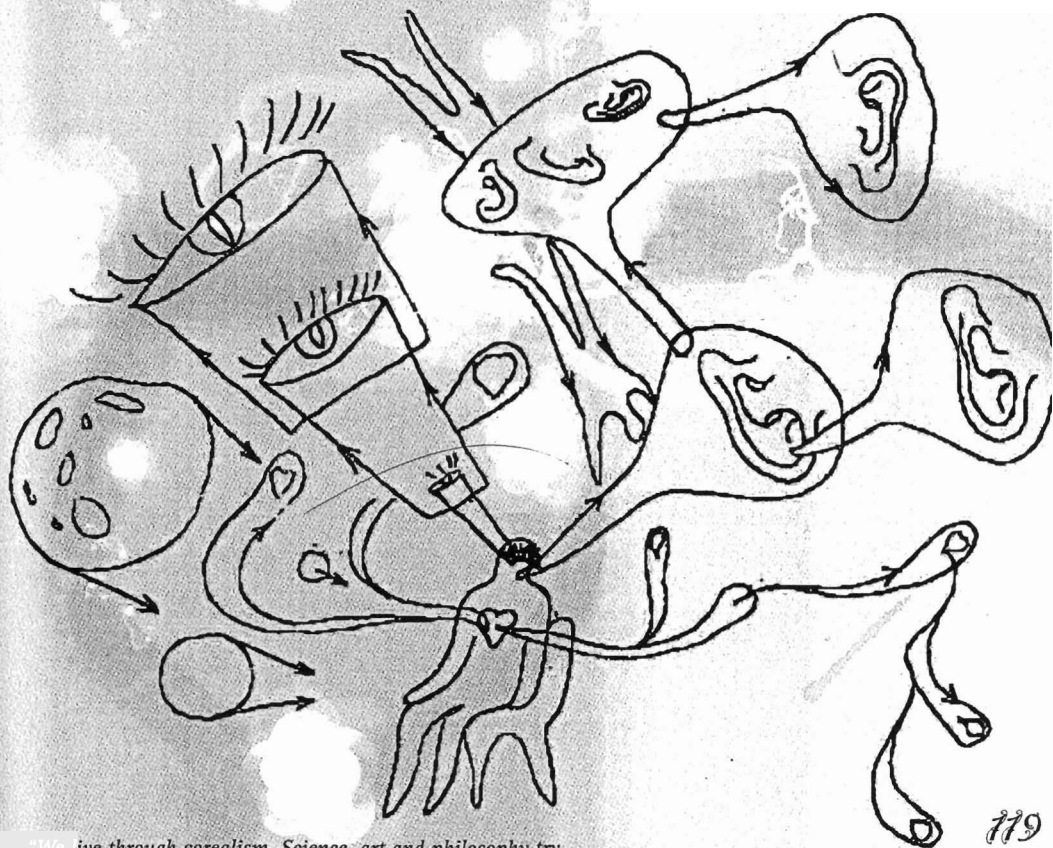
human organism in its milieu, but now stresses the interactive, dynamic, and inventive dimension of that relationship. Interactions taking place in society, technology, art, every sphere of activity – this is a holistic notion of interactivity. Through interaction, it's possible for us to expand. Now, that is exactly what human technology has actually facilitated. It has expanded our powers as creatures, and with those powers we can do either good things or bad things, constructive things or destructive things, and all kinds of things in between. But it's only through interactivity – that's my point here. For Kiesler, form ceases to be the key term, because forms are always contingent. They're fluid, changing, they're a moment in between: you go from formlessness to form and then back to formlessness, and it keeps going. Form as a concept becomes nested inside this dynamic model of the universe, and that changes it. Lissitzky put it beautifully back in 1924: "Every form is the frozen instantaneous picture of a process. Thus a work is a stopping-place on the road of becoming and not the fixed goal."

Was this also a Lebenslehre for Kiesler?

By implication, yes, but he didn't use the term or outline a way of living. It's an interesting horizon to think about: on the one hand, the model that is beginning to emerge by the middle of the 20th century conceives of form generation as self-generation within a field of interactive forces, agents and conditions, but then on the other hand it leads very quickly to interactivities that involve us. Our activities, too, are life activities. Kiesler again invokes the criterion of health. Health is a huge and underresearched topic in the history of ideas of the 20th century. We should really confront it today in the field of architecture, but I don't think we are equipped for that right now, at least not on my side of the Atlantic.

So in the mid-20th century it's interactivity that produces form, while in earlier ideas about bioconstructivism, like Ernst Haeckel's, there was no interactivity involved?

Yes, but I'd like to add a nuance to that. Your question takes us to another related topic. For in Haeckel's *Kunstforme der Natur* ("Art Forms in Nature," 1904) he presents the radiolarian as an exemplar of an organism – microscopic, single-celled, elemental in that regard – that has over 4,000 variations around the world. Each variation is adapted to its immediate environment. Their seemingly boundless variety and beauty, which is what led Haeckel to offer them as models for art, is related to their adaptivity, which is related to interactivity.

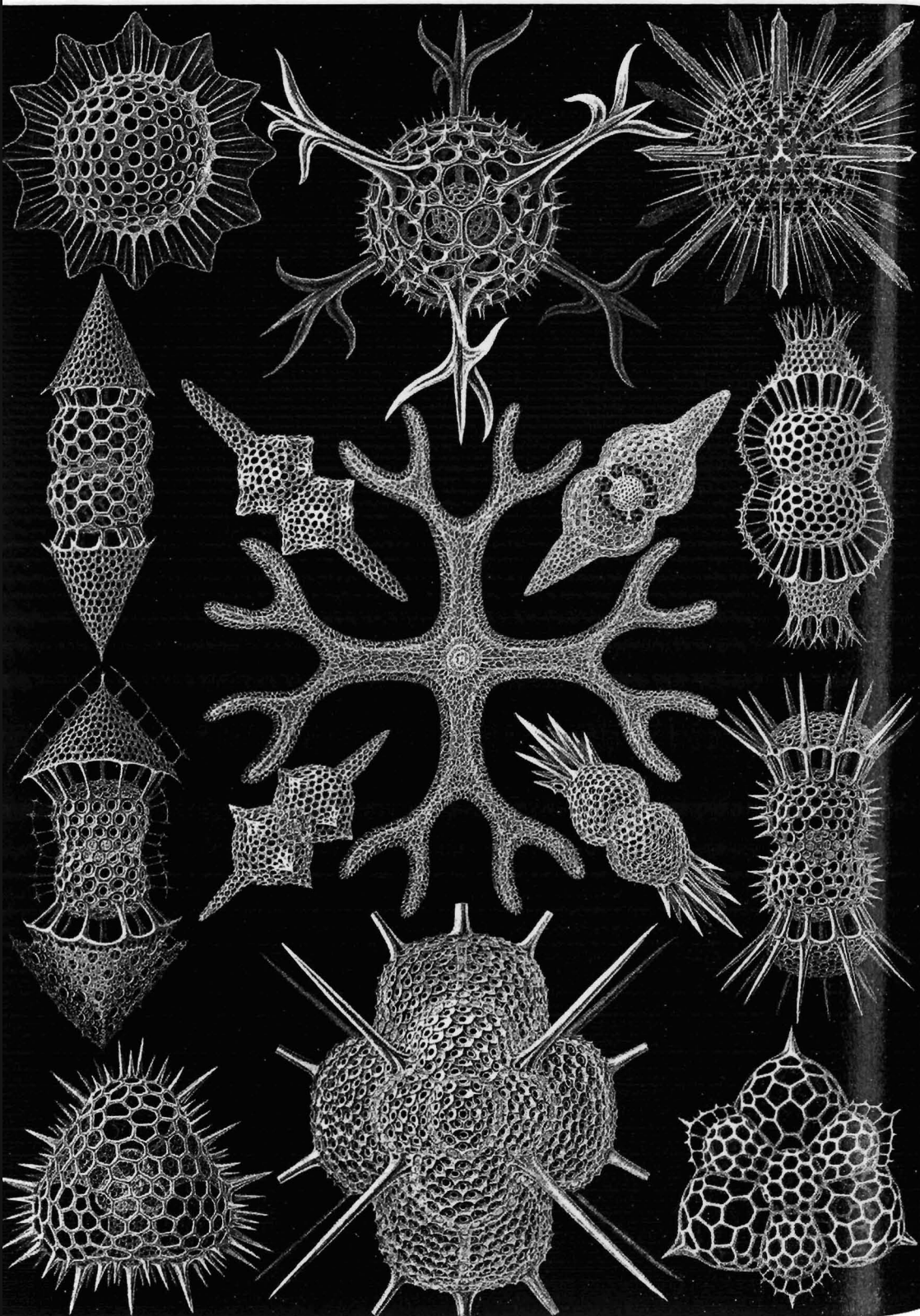


"We live through corealism. Science, art and philosophy try to make us understand this fact, more and more, deeper and deeper, richer and richer. All our being is conditioned by a consciousness of corealism."

Frederick Kiesler, drawing, 1937.

But Haeckel sees form more as a mathematical construct than as the outcome of a biological process.

He sees their form in terms of crystallography or a mathematical model, and that's of course what's greatly interesting to the engineers later on, to Le Ricolais, to Buckminster Fuller and others. But Haeckel is a biologist first and foremost. And the division between biology and mathematics is not so



Spumellaria. — Schaumstrahlänge.



Phaeodaria. — Rohrstrahlänge.


strong: Mathematics is a tool within biology. Just as the division between biology and physics nowadays is not so strong because it's blurred through the mediation of mathematics. Typical for Haeckel was that he wanted to see regularity and uniformity within the individual organism. More recently, using much more powerful microscopes than Haeckel had, Frei Otto and his researchers discovered that the structure of the radiolarians incorporates eccentricities and irregularities. They're not pure. There was a huge emphasis in the late 19th and early 20th centuries on purity and regularity, which you get in Haeckel, and of course also in Mies. But that's not to say that there is no conception of process or interactivity. Haeckel is the person who coined the discipline of ecology, as the study of the interrelationship between organisms and their environment. Organisms are also understood to be building their environments. They're making the environment while the environment is making them.

There is a chapter in Raoul Francé's book Die Waage des Lebens ("The Balance of Life," 1921) in which he describes a visit to Haeckel, who was his teacher. And then Francé illustrates the difference between Haeckel and himself. Haeckel says: I've shown all the forms of nature, and now my drawings can be used as a template for making new art. And Francé says: No, you shouldn't look at the forms, you should look at the problem that is solved by the form, and when you want to solve the same problem in engineering, use the same method as the organism used in solving it by producing its own specific form.

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You're right. There's a far greater emphasis on problem-solving in the 1920s and in Francé. But I still consider Haeckel to be a proto-bioconstructivist. For one thing, he was a monist – he was the person in whose honor the Monist League was formed. And he wrote books on how even society and government should be modeled on nature. I don't want to make bioconstructivism too big a term historically. If the field of people and theories becomes too big, it also becomes too fuzzy. For instance, Frank Lloyd Wright is famous for advocating organic architecture, modeling architecture on nature, and yet even within his oeuvre there are so many iterations of what that is formally that it becomes dizzying. From his early work to the Guggenheim, there's a world of difference.

Other historians have shown – I'm thinking of Caroline van Eck's *Organicism in 19th-Century Architecture* (1994) – that organicism has been integral to architectural theory within the Vitruvian tradition since Alberti. If we read Alberti, he advises architects to emulate the way in which nature achieves unity, harmony and wholeness, and also to emulate nature's methods of construction. What Van Eck does in her book is to trace continuity in




architectural theory from the Renaissance through to the end of the 19th century along these two guiding principles. There are so many architects who have aspired to something like biotechnics or bioconstructive activity. Of course, recourse to natural models has not always led to bio; in some cases it's crystals. For example, in Fröbel's educational pedagogy – Fröbel was trained as a crystallographer and many of the toys or "gifts" he developed for kindergarten learning, which were intended to allow the children to understand the order of the universe intuitively, are informed by a crystallographic paradigm. Crystals fascinated a lot of people in the 19th century and later because they grow and exhibit a vital force but they are inorganic, not organic. Incidentally, that made them seem more effective as models of purified engineering and mechanical technologies.

The problem with crystals as a model is that there is a difference between self-ordering and self-organization. Crystals are self-ordering, which is a very different process than the self-organization you find in organisms.

It would be very interesting to look at how the term "organization" came into discourses on architecture and art. It's there, for example, in Hannes Meyer's 1928 manifesto *Bauen*, in which he says: Building is biology, it's organization; it's a technical process, not an aesthetic process. Unlike Lissitzky, who had no issue with art, Meyer wanted to get rid of art. He wanted building to be pure construction and pure organization. That is informed by biological notions of interrelationships. Organization means establishing relationships among cells, atoms and other components, which are then mutable, which can change, which are conditioned by what Meyer calls "forces." It involves coordination as well. "Building is the deliberate organization of the processes of life... nothing but organization: social, technical, economic, psychological organization." Of course, organization becomes a much bigger topic in the 1950s and '60s with people like Gyorgy Kepes and cybernetics. And it's a big topic again today, whether it's self-organization or the organizational logics of global capitalism.

What is the relation between organization and form in architecture?

For the people we've been talking about, form is the result of processes. They might define the process using the notion of organization. Form is a reorganizing of energy and matter into a contingent coagulation that may then dissolve again. Organizations are mutable, in motion. In chaos theory, organization is a principal figure used to describe how order emerges out of what seems to be completely disorganized, often suddenly and unexpected-



edly. Organization can produce patterns as easily as forms, tissues and structures that are extensive rather than discrete.

Form has had a tendency to imply individual entities that are bounded, whose outlines are well defined – have clear *Gestalts* – rather than things that are open and contiguous with their context. But it need not be that way, and already with the open plan of 1920s modernism, form was seen to be open, permeable, an organization whose boundaries were ambiguous. The specific arrangement of walls and openings and the sizing of spaces were conditioned by the things that are in the living world and in the environment as well, and the relationships that were desired with the environment. Siegfried Ebeling's book *Der Raum als Membran* ("Space as Membrane," 1926) puts forward such an open conception of form and refers to biology explicitly. As this notion of the open plan became canonized in the theory of modern architecture, it somehow lost its biologicistic references. It's interesting that the architects of bioconstructivism today hardly ever talk about space, let alone spatial dynamics or effects or space-time, as people like Moholy, Ebeling and also Siegfried Giedion did. I think that's a real limitation. Why limit the discussion to form so strongly? One of the many things that interests me about Lars Spuybroek's work is that it has never been just about form, but also about space, perception, effect and – of course – interactivity.

What makes the connection between Mies and his study of biology so strange is that Mies seems to be an absolute control freak, while the processes as described by Raoul Francé and used by recent "non-standard" architects like Spuybroek and Lynn are about self-organization, which is basically giving matter the space and opportunity to organize itself. Mies van der Rohe seems to personify the transcendent approach to architecture, as opposed to the immanent approach you find in Francé and biologicistic architects today.

That's a great question. Let me start by saying that when the idea of epigenesis is approached as pure presence, we get into considerable trouble. We take the organism out of its environment, out of time, out of history and evolution, out of its field of interactivity. And we reassert the opposition of human and natural, which is untenable. That opposition has been employed as a shorthand form of evaluation – natural good, human bad – a kind of purist morality, in fact. We need better terms of assessment than that, more precise and productive terms, ones that enable thought to travel fluidly between the human and natural, to explore their interrelationship and coevolution. That's where Kiesler's notion of co-realism could be developed. Incidentally, claims to self-organization by Spuybroek and Lynn can easily be overstated since both use methods that are highly scripted and artificial.

Neither digital animation modeling nor material analogical modeling is nature in itself; rather, they are biotechniques in Kiesler's sense. Both architects select or develop specific methods to use from among many available, with some task or some probe already in mind. Then they produce many variations, from which they choose one to develop, judging somehow – intuitively, most often – that it has more potential than the others for the task at hand, be it a skyscraper or a house or a façade.

In Mies, the relationship between immanence and transcendence is certainly not clear, as it is not clear in a lot of others. But he had a powerful impulse towards immanence. Mies was a reader of Henri Bergson. His library included a copy of *Creative Evolution*. And he tells us that he learned from Whitehead. Both are important philosophers of immanence who cross over into science. Your question refers to the end result, the building as built, which is indeed totally resolved. All the different scales of the building are brought into alignment, from the superstructure to the details of joints. But it's very interesting to think of Mies' method of working. Mies would start slowly. There's a beautiful essay by Francesco Dal Co in which he talks about Mies' slowness as the result of wanting to wait for the right thing, the moment of presence that he could assist. He thought of architecture as service in that regard – not unrelated, of course, to the old idea of the genius as a conduit for the divine.

In 1926, Mies said, in a debate with the editor of the Werkbund journal *Die Form*, "Isn't the title of your journal too strong?" Because form is not an a priori or even the goal but the result of a process. And you don't know the result of that process until it's over. Mies was thinking here about the notion of *Gestaltung*, which Francé's writings reinforced, but which Mies would have known from the group around Hans Richter, of which Mies was part, and their journal *G. Gestaltung* means "form creation." Mies took issue with the editor of *Die Form* for being overdetermined in his attitude towards form.

Mies often designed through probes and alternatives. Especially in furniture, you see this very clearly, but also in some of his buildings, where he's mapping out a range of possibilities and then chooses to develop one. He said things like "I don't design buildings, I develop them." That was his ethos. But he was looking for the objective solution, the optimal solution, with minimal means, in harmony with the cosmos, and so brought the building into alignment with what he understands to be the order of the universe. Geometry is a big part of that order. Is the result transcendental? I don't know. It's interesting that each building is different in the end, even those that seem very similar. Most are very different – from the Barcelona Pavilion to the Farnsworth House. There are similarities, of course, but also big differences.

One of the things that's very interesting about all this material from the 1920s – and this pertains to Mies as well – is the idea that architecture could be redefined as a medium of elements and techniques. Think of the Bauhaus curriculum, which is tremendously important, I think. Architecture is not a medium of predetermined motives, styles, plans, organizations. These architects from the 1920s tried to identify what the constituents and logics of the medium were – just as Kandinsky had already done for painting before the war – and how one could use the medium to create desired effects – light and dark, rough and smooth, transparency and opacity, et cetera. They articulated its logic of assembly in terms of montage. That is consistent with the theory of *Gestaltung*, and it's not an accident that the subtitle of the magazine *G* is "*Material zur elementaren Gestaltung*." Meaning, what are the materials and means of elementary form creation? Mies often referred to the means of architecture in that period of time. So if, at the end of the day, his building is square, like the Neue Nationalgalerie in Berlin, the square is presumably both immanent and transcendent. Perhaps one could also say that for Mies transcendence was immanent as well as imminent. Today, you are right to be skeptical. But it's hard to distinguish what's transcendent and what's immanent there. On the other hand, Mies' approach may be helpful since it incorporates both preformation and epigenesis, which is essential for any theory of emergence.

This is also the problem for interactive artists: are we prescribing or determining form and behavior? Are we making means for a specific experience, or are we creating conditions for what has been called the experimental exercise of freedom?

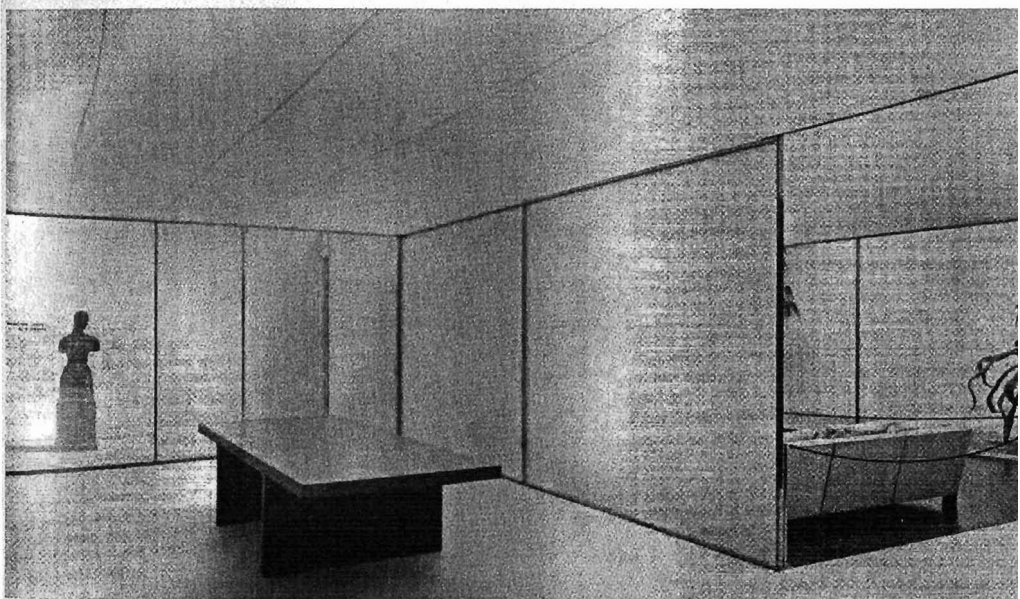
Well, another thing with Mies – probably in some ways more clearly than with other architects – is that his buildings stage experiments in living. This takes us to the theme of interactivity, of people living and acting in relation to architectural or art constructs. For instance, the pavilion of the Neue Nationalgalerie is not a conventional space for the display of art. It is big, empty and open to the outside on all sides. And Mies knew very well that he was creating a problem for the curators, who complained when the building opened that they had a hard time displaying easel paintings in the big space. But Mies said, "Maybe there's a better way to do it." And he didn't want to miss that. He deliberately provoked new ways of displaying art, perhaps even new ways of producing art. Well rehearsed in the environmental ambitions of modern art, he probably thought that easel painting was over and saw that large mural works were being made by Picasso, Pollack, and others. If we track through the history of exhibitions in that space over the last 30 years, we see some shows that were brilliant in relation to the building, and

some shows that were miserable because they did not respond to it at all. Mies provided a challenging architecture. In the last ten or fifteen years there have been rather extraordinary installation pieces by Jenny Holzer, Matt Mullican and Ulrich Rückriem and equally poignant exhibition designs by Toyo Ito and Rem Koolhaas. Koolhaas' *Content* was brilliant. Mies certainly didn't anticipate site-specific art, but the combination of structure and openness in the building has provided a great framework for it.

In the 1920s and again in the 1950s and '60s, modern architecture was preoccupied with supporting and provoking new ways of living – treating life itself as an experiment. Making form was experimental, and the way of life was also not predetermined – back to France. Architecture was intended to open the way for and support experiments in future paradigms of living. In Mies' case, that had to do with living outside as much as inside, blurring the boundaries between the outside and the inside, gardens and buildings. Later, in the universal spaces of his American work, like Crown Hall, there's as much provocation at play as already conceived ways of occupying the building.

Mies was developing his architecture in relation to the user?

Ludwig Mies van der Rohe and Lilly Reich, Glass Room,
German Werkbund Exhibition, Stuttgart (1927)



I think so. For instance, in the 1920s, he was a friend of Hugo Häring; they shared a studio. But he criticized Häring for wanting too tight a fit between form and function. Häring would design houses where the hallway to the bedroom would become narrower towards the end because fewer people would be using it. And Mies used to say, "Why not make a really big hallway so people can use it for many different things?" The question of sizing and scale comes up here. Mies has a very generous scale, and in part that's intended to permit a variety of ways of occupying these spaces.

Let's jump to more recent bioconstructivism. One of the fascinating aspects of the work of the so-called non-standard architects of today is that although the relationship between the elements of the building is clear, the relationship between the building and the user is sometimes problematic.

That takes us back to the tension between a focus on form and a focus on function or program or event. Sometimes architects choose one side or the other of this binary opposition. But these are not mutually exclusive by any means, and somebody like Kiesler makes that very clear. In the 1939 essay that I quoted earlier, he speaks of structure as a third term to which both form and function need to refer. He calls for an understanding of form, function and structure as interrelated, which suggests that all three are related to organization. If we think of structure as organization of relations rather than physical structure alone, and recognize that organization is always dynamic and interactive even when it appears to us as static, then we have more tools to deal with and can easily integrate the users and their ways of living or working or playing. This kind of integrated approach has yet to be adequately theorized in contemporary "non-standard" or bioconstructivist work, although any good architect will pursue integration as a matter of course, will seek to have their design perform on many levels.

It is a big shortcoming in contemporary work that organizational relations – which are ones of inhabitation, function, use, ways of living – do not play a stronger formative role. Perhaps, like Mies, we would want to avoid Häring's overdetermination of form by a reductive conception of function. Kiesler, too, was critical of the maxim that form follows function; he suggested instead a progression of (1) structure, (2) function, (3) form. "All functions and all forms are contained in the structure," he said. Mies developed his clear-span structures – the so-called universal spaces – in order to be flexible with respect to use. He said, "Functions change so rapidly today, but buildings don't, so you can't design form for function." But at the same time, his buildings worked very well, and even graciously. He managed to negotiate a delicate relationship between structure and function while also remaining open to change, to things that aren't expected. Perhaps there's a

reason why the generic loft space or column grid space – Le Corbusier's Domino extended – has become so ubiquitous, successful and durable. In that regard, it's interesting to think that contemporary bioconstructivist work on extensive structures could update this model. Reiser+Umemoto, Lars Spuybroek, Zaha Hadid have all produced some projects that do that.

The recent avant-garde has often ascribed a kind of open-endedness in use and experience to curved and sloping surfaces. Think of Spuybroek's Fresh Water Pavilion, which was a fantastic and amazing project at the time and opened up a new trajectory for many others. The argument that sloping surfaces are open to interpretation in terms of use is true, but they're also not very handy for many things. They're good in some ways but not in others. A child can run up them or sit on them, but what else might people want to do and what support do they need for that? How can one incorporate an open-ended but nevertheless pragmatic conception of use into the process of generating form? This was a question that confounded the architects of De Stijl at first too, and the early Bauhaus, which was accused of formalism. To me, it seems as odd today when architects rely on a single formal language for everything as it did when Gropius designed his first office at the Weimar Bauhaus using cubic forms for everything: the desk, the lamp, the wall textile, the armchair, the teapot, et cetera. Even though we enjoy the voluptuousness of the new curved language, why not accept that different geometries can coexist in built environments as they do in nature?

The task at hand is the integration of multiple parameters and objectives into the new generative approach to design. As David Ruy always points out to me, geometry is inherent to matter and material organizations, of which human life is one example. Even though geometry is a human discovery, if not invention, it's in the universe. Having developed some remarkable tools over the past few years for generating form using models sets from nature or science – I'm amazed by the work with algorithms that Cecil Balmond, David Ruy, Jenny Sabin and Ben Aranda are doing here at Penn as much as the diagrammatic work derived from coral and tree bark that Rhett Russo, Bill Braham and Annette Fierro are doing – the challenge now is to extend the rigor of those initial techniques through the rest of the design process and construction. And not lose the experimentalism and open-endedness. Architecture requires an anthropological and cultural imagination as much as an architectonic one. Inclusiveness and interactivity are key to both. As Kiesler said, our mission should be to nurture alternative ways of living – and expanded horizons of experience – through new structures. At Penn, Matthias Hollwich did a studio last semester on symbiotic resorts and leisure, which had that spirit, and also humor and irony, which I appreciate since this can all become much too serious.

There's a task here, a substantial task for the discipline, because without integration of the many dimensions that make architecture tick, this kind of work is vulnerable. It's vulnerable to critique; it's vulnerable to obsolescence; it's vulnerable to not being realized. It's simply inadequate to the multidimensional nature of architecture as a discipline. It's where architectonic invention slides into sculpture. Sculpture doesn't have to have uses, at least not traditional sculpture, other than to inspire and amuse and provoke in its reception. The reception of architecture is in its occupation and performance as well as in its perception. The challenge is to put aside either/or thinking and develop habits of mind that are inclusive. I think interactive art has many lessons for architecture in this.

Do you consider bioconstructivism today as a flourishing field with a lot of potential?

Yes, it's extraordinary and inspiring. It's fueled a lot of formal and structural invention through digital media and material experiments. It's expanded the discipline. Now, we have to find avenues to draw research and knowledge together that's currently housed in different silos within the discipline. There's so much innovation taking place in engineering – structural, environmental engineering – that we need to integrate. There's lot of potential, also, in integrating intelligence to make buildings that are responsive. At Penn, Ferda Kolatan is leading an effort to do that, as he has in his own work. All this is on top of the more effective engagement with uses and programming that we've talked about already.

At the same time, at least two additional issues have come into focus over the past few years, which also need to be embraced: environmental degradation and urban dynamics. The US is finally waking up to the issues of climate change and the need to get off oil and develop other sources of energy and other materials that are not petroleum products. In Europe, you are, of course, much ahead of us in all this. Global warming demands that we take responsibility for other interactivities than we have talked about so far. There is no reason why more buildings can't be generators of energy, rather than just consumers. Why not integrate that goal into the next generation of generative models for design? Karel Klein, for instance, has done studios here where students use patterning tools to design buildings that capture and circulate the maximum energy from the sun on a site in Philadelphia.

That's actually a good bridge into the question of urban dynamics – how architecture can contribute to the growth and development of cities and economies. In a lovely book by the late Jane Jacobs, *The Nature of Economies* (2000), she describes how economies grow, develop and expand using an ecosystems metaphor. She says it's helpful to think about how energy passes

through ecosystems, what kind and how many transformations of energy and matter take place. In desert ecosystems, less happens than in well-developed forest ecosystems. In a desert or a parking lot, sunlight heats things up but doesn't get circulated much and basically disappears. In the forest, energy is circulated in a web of teeming, interdependent and interacting organisms, plants and animals. It's not just converted once but many times, combined and recombined, cycled and recycled, passed around from organism to organism. That's how diversity, intricacy and complexity develop. The flow of energy, she says, is "dilatatory and digressive," leaving behind complex webs of life. It's worth thinking about how the design and making of buildings can enrich ecosystems – human as well as natural – by circulating and recirculating energy. Literally in terms of the energy they use or produce. If they produce energy, not only will this offset global warming, but that energy can be sent into the world to circulate more and in more productive ways. But we can take this less literally, too, if we think of the economies and urbanisms in which the production of buildings participates – their maintenance and transformations over time, too. We know that they can be catalytic within urban economies, whether it's Gehry's Guggenheim energizing the economy of Bilbao or more ordinary projects for housing, schools and retailing in local neighborhoods. It seems to me that this, too, would be in the spirit of an updated bioconstructivism. Some architects have worked in this direction, but not, as far as I know, the more formally oriented neo-avant-garde, even though they have now embraced issues of material fabrication and have sometimes talked about their work as catalytic. It's time to radically expand the sphere of interactivity and effects that architects engage, to become serious and activist on that front. We need to develop inclusive habits of mind, to embrace the so-called real world, and work towards attaining multiple goals. There are many issues and resources that can be harnessed and brought together with experimental form-making; it's a tremendous horizon. Without bringing all that together, it seems to me that pure, disinterested experiments in form are inadequate to the tasks that face architects today.

